A LATE PERMIAN BRACHIOPOD FAUNA FROM SELONG, SOUTHERN XIZANG (TIBET), CHINA

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A brachiopod fauna from the middle part of the Selong Formation of the Selong Xishan (West Hills) section, southern Tibet is described and includes *Taeniothaerus* sp., *Chonetella nasuta* Waagen, *Lamnimargus himalayensis* (Diener), ?*Lamnimargus* sp., ?*Echinauris* sp., *Cleiothyridina* sp., *Posicomta grunti* sp. nov., *Spiriferella rajah* (Salter), *Neospirifer kubeiensis* Ting, *Trigonotreta* sp., and Spiriferinacean gen. et. sp. indet. This fauna is correlated with the *Lamnimargus himalayensis* Zone of the Himalayas. The age of the *Lamnimargus himalayensis* Zone is discussed and considered to be Midian to Early Dzhulfian (Late Permian).

PERMIAN marine strata are extensively distributed in Tibet, occurring in all the four major tectonostratigraphic blocks (or terranes) (Fig. 1), and contain abundant invertebrate fossil remains. Brachiopoda are among the most abundant and diverse fossil groups present and have long been used as an important biostratigraphical tool for correlating the Permian marine sequences between the blocks and between Tibet in general and other Gondwanan regions. Biogeographically, Tibet is of particular interest because of its position between Eurasia to the north and Gondwana to the south. However, contention remains over the placement of the palaeobiogeographical boundary between the Gondwanan and Palaeo-Equatorial Realms (Sun 1993; Shi et al. 1995). This ongoing debate is in part due to insufficient knowledge of the stratigraphical and faunal relationships between the Tibetan blocks and between Tibet and Cathaysian and other Gondwanan regions.

A number of Permian brachiopod faunas have now been described from many isolated localities of southern Tibet (eg. Ting 1962; Zhang & Jin 1976; Jin & Sun 1981; Yang & Zhang 1982). Jin (1985) reviewed the faunas and established a biostratigraphical framework based on brachiopod assemblages. However, precise stratigraphical relationships among the previously described faunas remain to be clarified and detailed correlations of the Tibetan brachiopod faunas with known Himalayan brachiopod successions require refinement.

This paper describes a brachiopod fauna collected from near the Selong village in southern Tibet (Figs 1, 2) by one of the authors (SS-Z) in 1994. Zhang & Jin (1976) first described some brachiopod species from this section, but the detailed stratigraphical positions of their collections were not specified. Recently, the Selong section has aroused considerable interest among geologists because of its potential as a global stratotype of the Permian–Triassic boundary (see Jin et al. 1996 and references therein provided). Most of the previous studies, however, have concentrated on the Permian–Triassic boundary beds and associated faunas, with little attention given to the faunas from the lower and middle parts of the Selong section.

STRATIGRAPHY

The name Selong Group was first proposed by the Scientific Investigation Team of the Chinese Academy of Science to Mt Xixiabangma in 1964 (unpublished; see Mu et al. 1973), with the type section at approximately 1 km northwest of the Selong village along the Tingri–Gyriong Highway, on the northern slope of Mt Xixiabangma (Fig. 2A). The unmeasured section was later described by Zhang (1974), with an estimated thickness more than 200 m assigned to the Permian. Rao & Zhang (1985) measured the type section and divided the Selong Group into two units: Mengdou Formation of Lower Permian, followed by the Baka Formation of Upper Permian, despite both formations of this section being characterised by bioclastic limestones with minor interbeds of shale and sandstones. Rao & Zhang (1985) also discovered a transitional or mixed fauna of Permian–Triassic character at the top of the Baka Formation and, as a consequence, suggested that the Selong section might represent a continuous Upper Permian to Lower Triassic sequence.

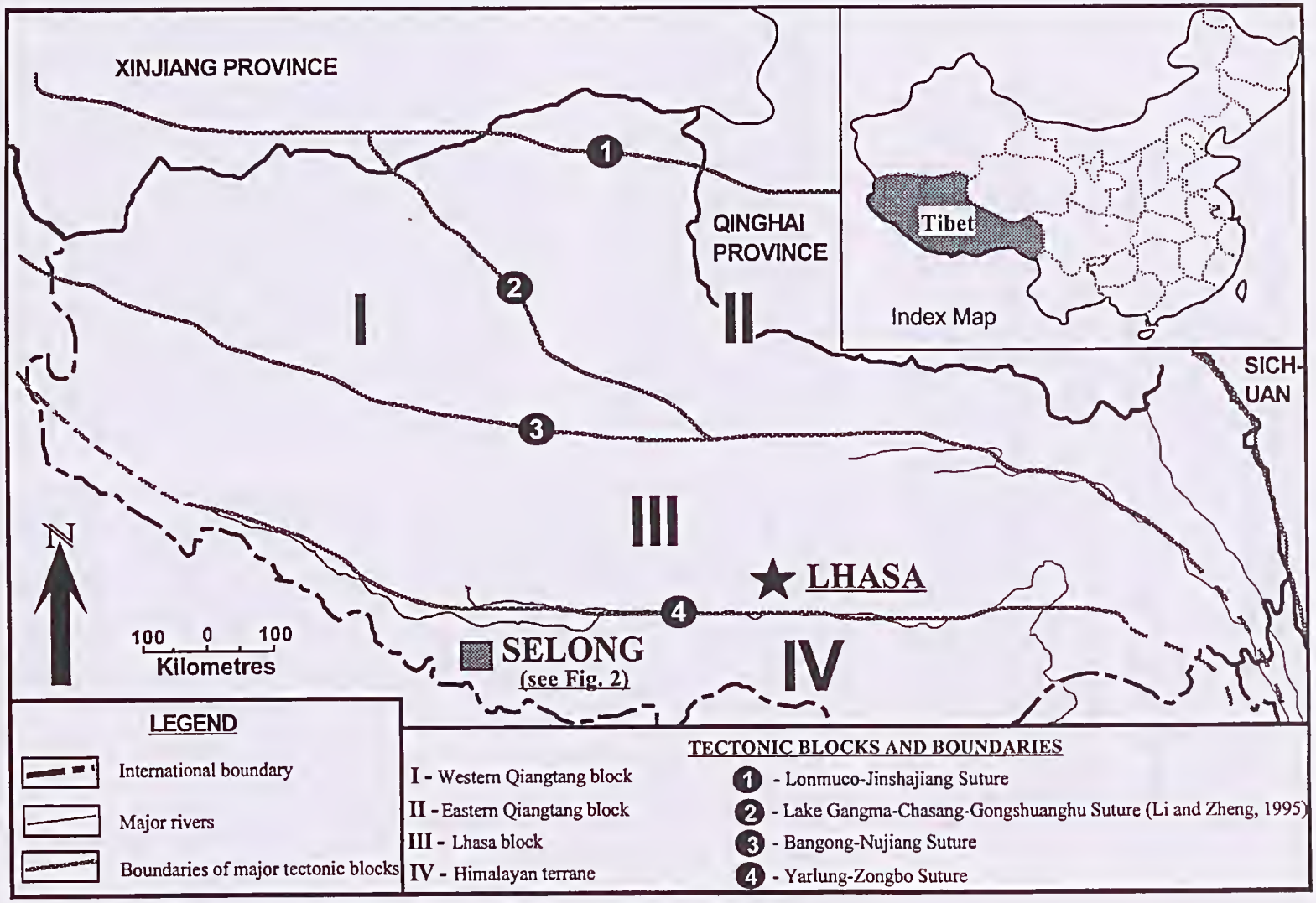
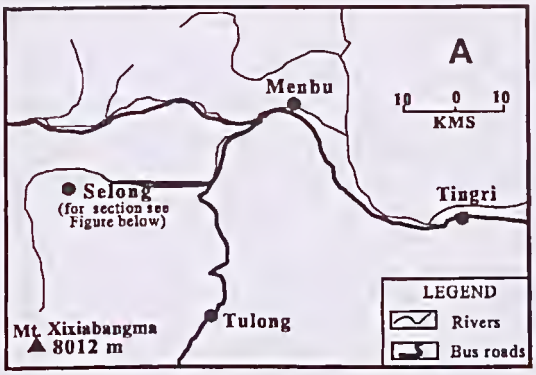


Fig. 1. Map showing major tectonostratigraphic blocks in Tibet and location of the study area.



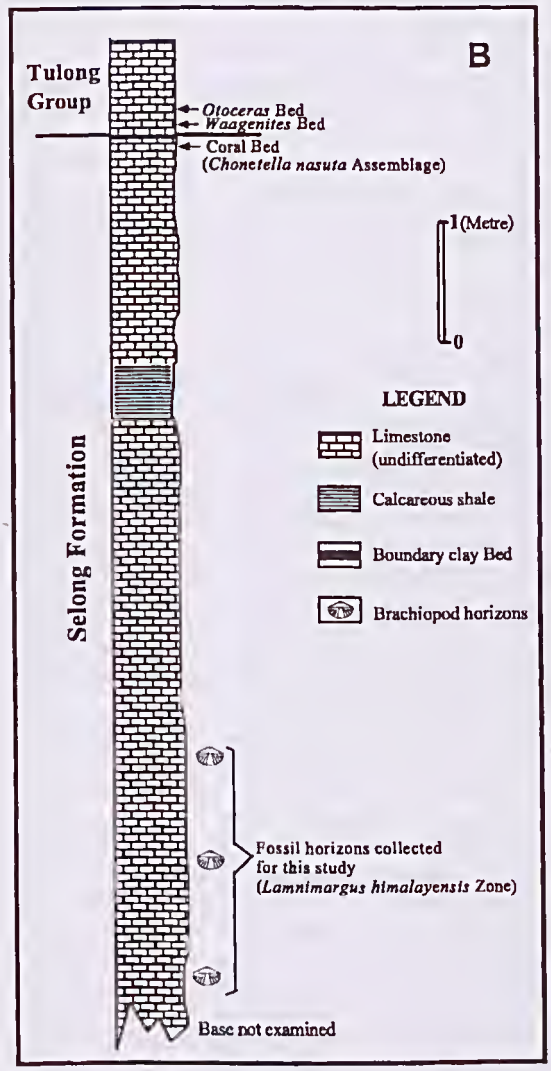


Fig. 2. A, detailed location map of Selong in southern Tibet. B, measured stratigraphic column of the Selong Formation at the Selong Xishan (Western Hills) section.

More recently, Wang et al. (1989), in an attempt to reveal the stratigraphical details of the supposedly continuous Permian–Triassic boundary at the Selong section, measured the section and divided the Selong Group into two parts; the lower part, named the 'Pre-Changhsingian Beds', was estimated to be 28.76 m thick and was characterised by grey to dark-grey limestones occasionally interbedded with calcareous shales. The upper part, called the 'Changhsingian Beds', was measured 0.06 to 0.17 m thick and was identified by grey and dark-grey limestone with a thin layer of clay and contained characteristic 'Changhsingian' conodonts and brachiopods. A further modification to the subdivision and nomenclature of the Selong Group in the Selong area has been proposed by Jin et al. (1996), who referred the carbonate-dominated Permian sequence to the Selong Formation, and the overlying dolomitic limestone facies to the Tulong Group, with the Permian–Triassic boundary being placed at the base of the '*Otoceras* Bed' within the lower part of the Tulong Group (Fig. 2B). It is noted that in this scheme, which is also followed herein, the previously regarded uppermost calcareous shale-dominated unit (the so-called '*Waagenites* Bed') of the Selong Group is now placed at the base of the Tulong Group (Fig. 2B).

The brachiopods described in this paper were collected from the middle part of the Selong Formation in the Selong section, from beds characterised by coarse bioclastic grainstones. The grains are dominated by poorly sorted broken brachiopod shells and crinoid stems; and the matrix is dominated by highly calcareous micrite and silt. The brachiopod specimens are abundant, but mostly fragmentary and disarticulated.

The fossils described in this paper are registered with the prefix NMV P and housed in the type collections of the Museum of Victoria, Melbourne.

AGE AND CORRELATION

In their study of Late Palaeozoic brachiopod faunas of Tibet, Zhang & Jin (1976) divided the brachiopod succession of the Selong Formation and equivalents in southern Tibet into two assemblages: the lower *Taeniothaerus* Assemblage characterising most of the Selong Formation, and the upper *Chonetella* Assemblage that occurs at the top of the formation. This latter fauna was later renamed the *Chonetella nasuta* Assemblage by Jin (1985). In a more recent study specifically on the brachiopods of the Selong section, Jin

et al. (1996) grouped the brachiopods of the Selong Formation from this section into a lower '*Marginifera*' (=*Lamnimargus*) *himalayensis–Spiriferella* Assemblage and an upper *Chonetella nasuta* Assemblage and restricted the latter assemblage to the top layer (their 'Coral Bed'; see Fig. 2B), just below the Permian–Triassic boundary 'Clay Bed'. The brachiopod material described in this report was collected from limestone beds about 5 m below the 'Coral Bed' and belongs to the '*Marginifera*' *himalayensis–Spiriferella* Assemblage (Fig. 2B).

In terms of species composition and stratigraphical position, the '*Marginifera*' *himalayensis–Spiriferella* Assemblage appears correlative with the *Lamnimargus himalayensis* Zone of Waterhouse (1976) and Waterhouse & Gupta (1977, 1983a). This zone, originally based on the Permian faunal sequence of Panjang Kola in the Dolpo district, northwest Nepal (Waterhouse 1976: 142, 143), was said to be typified by the brachiopod faunas of the lower Zewan beds (faunal Division I and II of Nakazawa et al. 1975) as originally described by Davidson (1862) and Diener (1899, 1915), with the following key species: *Neochonetes vishnu* (Salter), *Waagenoconcha gangeticus* (Diener), *Lamnimargus himalayensis* (Diener), *Costiferina alata* Waterhouse, *Anidanthus fusiformis* Waterhouse, *Spiriferella rajah* (Salter), *Neospirifer moosakhailensis* (Davidson), and *Fusispirifer nitiensis* (Diener) (Waterhouse & Gupta 1977). Two of these, *Lamnimargus himalayensis* and *Spiriferella rajah*, are also common in the Selong collection described herein, with a third species, *Neospirifer moosakhailensis*, being also closely comparable to *N. kubeiensis* Ting from the Selong assemblage. Several other diagnostic species of the *Lamnimargus himalayensis* Zone, though not recorded in this paper, have also been reported by Zhang & Jin (1976) from the Selong Formation near Selong and include *Costiferina alata* Waterhouse, *Anidanthus fusiformis* Waterhouse and *Fusispirifer nitiensis* (Diener).

The *Lamnimargus himalayensis* Zone appears to occur widely in the Himalayas, as reviewed by Waterhouse (1978) and Waterhouse & Gupta (1977), but only a few faunas have been systematically documented and many require modern revision. Important correlative faunal horizons include the Kalabagh Member of the Wargal Formation and, also possibly, the lower part of the Chhidru Formation of the Salt Range in Pakistan as described by Waagen (1882–1885) and Reed (1944) and discussed and reviewed by Grant (1970), the unnamed carbonate unit within the Shyok melange near Shigar, Baltistan, Pakistan (Brookfield & Gupta 1984), the upper Kuling Group (formerly 'Kuling Shales') of Spiti, Lahaul and Zanskar (northwest India) (Garzanti et al. 1996), an unnamed metamorphosed silty shale unit in the upper Shoyok Valley in the Karakorum Range (Waterhouse & Gupta 1983b), the Lachi Group of North Sikkim (Muir-Wood & Oakley 1941), the unnamed micaceous shale beds of Kumaon and Garhwal (Diener 1897b, 1903), the '*Costiferina* arenites' unit of the Thini Chu Formation in northwest Nepal (Waterhouse 1966, 1978; Garzanti et al. 1992) and the 'Member C' of the Puchenpra Formation of central Nepal (Garzanti et al. 1994), and at least part of the Chitchun No. 1 Limestone of southern Tibet (Diener 1897a, 1903; Jin 1985).

The age of the *Lamnimargus himalayensis* Zone appears to be Midian–Early Dzhulfian, according to ammonoids and fusulinids found either in direct association with the brachiopods or immediately above the brachiopod horizon. In Kashmir, the basal two faunal divisions (Divisions I and II of Nakazawa et al. 1975) of the Zewan Formation, which provides the best reference section for the *Lamnimargus himalayensis* Zone (Waterhouse & Gupta 1977), is immediately overlain, without obvious hiatus, by faunal Division III, which contains a distinct *Cyclolobus* fauna of principally Dzhulfian age (see Glenister et al. 1990). The presence of *Cyclolobus*, overlying the *Lamnimargus himalayensis* Zone, therefore, sets an upper age limit for this brachiopod zone to be no younger than Dzhulfian. A similar stratigraphical relationship between *Cyclolobus* and the brachiopod zone has also been recorded within the Gungri Formation of the Kuling Group in Lingti of the Spiti Valley (northwest India), where *Cyclolobus walkeri* Diener of Dzhulfian age was found some 50 to 60 m above the *Lamnimargus himalayensis* Zone (Garzanti et al. 1996: 184).

The age of the *Lamnimargus himalayensis* Zone may be also inferred through its correlation with the Kalabagh Member of the Wargal Formation. Nakazawa & Kapoor (1979) have reported *Neoschwagerina* aff. *margaritae* from the lower Wargal Formation, *Colaniella nana* and *C. minima* (a key species of the Japanese Late Permian *Colaniella minima–Nanlingella simplex* Zone, of Dzhulfian age) and *C. pulchra* from the lower Chhidru Formation. These findings have confined the age of the Kalabagh and lower Chhidru Formation to the Midian–Dzhulfian range in terms of the Tethyan timescale (Leven 1992) or, by inference, the Capitanian–Wujiapingian in the framework of the newly proposed three-fold Permian timescale (Jin 1996).

SYSTEMATIC PALAEONTOLOGY

Order PRODUCTIDA
Sarycheva & Sokolskaya, 1959

Suborder STROPHALOSIIDINA
Waterhouse, 1975

Superfamily AULOSTEGACEA
Muir-Wood & Cooper, 1960

Family AULOSTEGIDAE
Muir-Wood & Cooper, 1960

Subfamily AULOSTEGINAE
Muir-Wood & Cooper, 1960

Genus **Taeniothaerus** Whitehouse, 1928

Type species. *Productus subquadratus* Morris, 1845.

Taeniothaerus sp.

Figs 3A–B

Taeniothaerus cf. *subquadratus* (Morris), Zhang & Jin 1976: 171, pl. 4, figs 1–3, 15–16.

Material and description. One incomplete ventral internal mould, NMV P145670, with part of the external mould of the ventral interarea attached. The valve is large, approximately 50 mm long and wide, 25 mm high, widest at midlength or near anterior margin, subquadrate in outline, strongly convex at midlength. Interarea approximately $^2/_3$ the maximum width, low, 8 mm high, concave, marked by very fine vertical striations, bisected by a narrow (1.5 mm) delthyrium, which is covered by strongly convex pseudodeltidium with a deep, V-shaped anterior notch about quarter the entire length of the pseudodeltidium. Sulcus prominent, commencing probably from umbo, broad and moderately deep towards anterior margin. Adductor scars relatively small and narrow, moderately raised, marked by few radial grooves; diductor scars large, lobate, strongly marked by elongate ridges, located mostly lateral to the adductor scars; rest of valve floor covered by slightly elongate pits, presumably reflecting external ornament. Several distinct concentric lamellae present at near anterior margin.

Comments. The present material is most like the specimens from the Selong Formation previously figured by Zhang & Jin (1976) as *Taeniothaerus* cf. *subquadratus* (Morris). The Selong species as a whole is characterised by a large size, subquadrate outline with a strongly curved lateral profile and maximum width being at or near the hinge line, and a well-defined ventral sulcus which is most pronounced over the mid-width of the shell. These characteristics suggest a strong similarity to *T. subquadratus* (Morris) from the Lower Artinskian Berridale Limestone of Tasmania, as redescribed by Parfrey (1983). However, little is known about the details of the ornament of the Selong species due to poor preservation, preventing a full comparison with the Tasmanian species. The overall shape and size of the Selong species also suggests *T. anotos* Briggs (in Waterhouse et al. 1983: 130, pl. 1, figs 6–10) from the Lower Artinskian of northern Bowen Basin, eastern Australia, but the latter appears to be more elongate in outline, with a shallow and broad sulcus. The well developed, strongly dendritic diductor scars of the Selong specimen also recalls *Megasteges* Waterhouse (1975), but the diductor scars of the latter are typically large and located lateral as well as anterior to the adductor scars.

Suborder PRODUCTIDINA Waagen, 1883

Superfamily PRODUCTACEA Gray, 1840

Family CHONETELLIDAE Likharev, 1960

Genus **Chonetella** Waagen, 1884

Type species. *Chonetella nasuta* Waagen, 1884.

Chonetella nasuta Waagen, 1884

Fig. 3C

Chonetella nasuta Waagen 1884: 613, pl. 81, figs 3–8.
Chonetella nasuta—Hamlet et al. 1928: pl. 3, figs 5–7
Chonetella nasuta—Muir-Wood & Cooper 1960: 219, pl. 69, figs 1–7.
Chonetella nasuta—Termier et al. 1974: 129, pl. 28, figs 4–5.
Chonetella nasuta—Zhang & Jin 1976: 172, pl. 4, figs 4–5 (with synonymy).
Chonetella nasuta—Grant 1976: pl. 42, figs 1–17.
Chonetella nasuta—Jin 1985: pl. 4, figs 26–27.

Material and description. This distinctive species is represented by a ventral internal mould with broken patches of the exterior preserved. The specimen is small, about 10 mm wide (ears partly broken), 14 mm long, sub-ovate in shape, maximum width at hinge line; strongly and evenly convex without abrupt geniculation, most convex at midlength; ears clearly defined, triangular in shape, slightly convex, well demarcated from strongly convex venter; umbonal slopes high and steep. Anterior margin notched to a narrow nasute extension, about 2 mm high and 3 mm wide. No reflection of external costellae observed on internal surface. Specimen too abraded to show details of muscle scars; no endospines or median septum.

Comparisons. Zhang & Jin (1976: pl. 4, figs 4–5) described and figured two ventral valves from the Selong Formation as *Chonetella nasuta*. A comparison of the combined characteristics of the present specimen and specimens figured by Zhang & Jin (1976) with the type material of *C. nasuta*

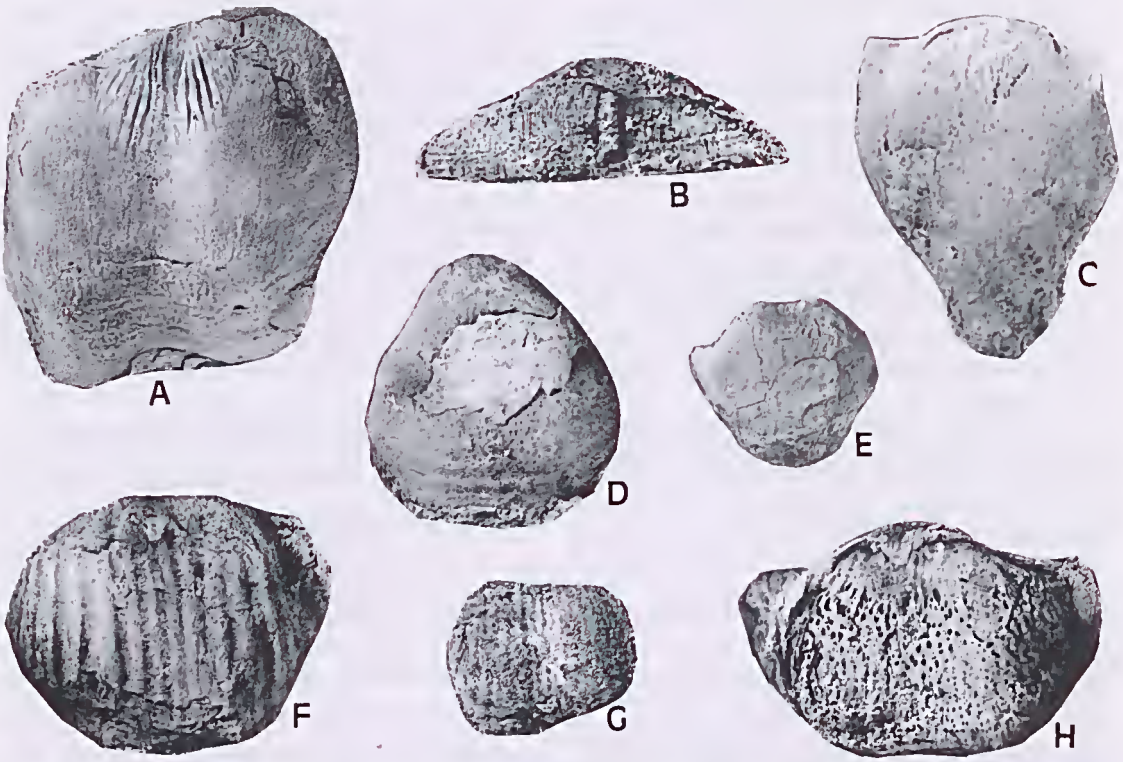


Fig. 3. A–B, a ventral internal mould and a latex cast of a ventral interarea of *Taeniothaerus* sp.; A, NMV P145670, ×1; B, NMV P145671, ×1.5. C, an abraded ventral valve of *Chonetella nasuta* (Waagen), NMV P145672, ×2. D, a decorticated ventral valve of ?*Echinauris* sp., NMV P145673, ×2. E, G, H, *Lamnimargus himalayensis* (Diener): E, an abraded ventral valve, NMV P145674, ×1; G, latex cast of a ventral external mould, NMV P145676, ×1; H, a ventral valve with interior partially exposed, NMV P145677, ×2. F, ?*Lamnimargus* sp., a ventral valve, NMV P145675, ×2.

as figured by Waagen (1884: 613, pl. 81, figs 3–8) and Grant (1976, pl. 4, figs 1–17) revealed strong similarities in all observed ventral details. Although no dorsal valves are available for the Selong form, the unique combination of its ventral characteristics, including a small size, strong and even convexity, moderate and well demarcated ears, weak to moderate costation, sparse spines restricted to along the hinge, and the presence of a distinctively notched anterior margin, serve to identify this form with *C. nasuta* and to distinguish it from other related species.

Likharev (1937: 12, pl. 13, figs 1–7) figured Upper Permian specimens from North Caucasus under the name of *Chonetella nasuta triangularis* var. nov. As the name implies, this species is characterised by a pair of large, laterally well extended ears; however, its median anterior notch is invariably small and short in comparison with that of *C. nasuta* from the Salt Range and Selong. The same seems also true of the specimen figured as *Chonetella nasuta* Waagen by Hamlet (1928, pl. 3, fig. 8) from Wesleoe, West Timor, considered by Likharev (1937) to be conspecific with *C. triangularis*. However, Hamlet's other specimens (1928, pl. 3, figs 5–7), also from Wesleoe, possess a pair of smaller, though still very distinct, ears, much like in the present specimen and those of *C. nasuta* from the Salt Range, although the notched anterior margin of the Timorese specimens appears less well developed in comparison with most specimens of *C. nasuta* from the Salt Range. Rothpletz's (1892: 77, pl. 10, fig. 12) single ventral valve from Ajer Mati of West Timor appears to virtually lack the notched anterior margin characteristic of *C. nasuta*, as does a similar ventral exterior figured by Archbold & Bird (1989: fig. 3A–B) from the Maubisse Formation near Kasliu, West Timor. It was noted by Archbold & Bird (1989) that the lack of the anterior notch may

have been due to preservation, this nevertheless underlines a need for further study and clarification of the morphological range of material from Timor.

Waterhouse (in Waterhouse et al. 1981: 76, pl. 8, fig. 14) figured an externally abraded ventral valve from the Ko Yao Noi Formation of southern Thailand as *Chonetella* sp. This form resembles the Selong specimen in shape and size, but appears to be more inflated in profile.

Occurrences. *Chonetella nasuta* was originally described from the Kalabagh Member of the Salt Range in Pakistan. Elsewhere, the species has been recorded from the Amarassi and Basleo beds of Timor, the Selong Formation of southern Tibet, and from the Wardak area of central Afghanistan (see synonymy list).

Superfamily MARGINIFERACEA Stehli, 1954

(nom. transl. Shi & Waterhouse, 1996 ex Marginiferidae Stehli, 1954)

Family PAUCISPINIFERIDAE Muir-Wood & Cooper, 1960

Subfamily RETIMARGINIFERINAE Shi & Waterhouse, 1996

Genus **Lamnimargus** Waterhouse, 1975

Type species. *Marginifera himalayensis* Diener, 1899.

Comments. The genus has been discussed in some detail by Waterhouse (1975, 1978). When defining *Lamnimargus*, Waterhouse noted the close similarity of the genus with *Retimarginifera* Waterhouse (1970), type species *R. perforata* Waterhouse, from which Waterhouse recognised distinctions in shell structures, spine pattern on the ventral valve and the presence or absence of anterior flanges within both valves. However, the statement that *Lamnimargus* possesses a cluster of finer spines over each ear remains to be verified. Equally uncertain is the supposed presence of the anterior flanges (marginal ridges) thought by Waterhouse to characterise *Lamnimargus*, but Angiolini (in Garzanti et al. 1996) has pointed out that these marginal ridges are not present in the type specimens of Diener (1899).

Lamnimargus himalayensis (Diener, 1899)

Figs 3E, G, H

Marginifera himalayensis Diener 1899: 39, pl. 2, figs 1–7, pl. 4, figs 1–2.

Lamnimargus himalayensis—Gupta & Waterhouse 1979: 8, pl. 1, figs 3–8 (with synonymy).

Lamnimargus himalayensis—Brookfield & Gupta: 1984: 41, fig. 7.

Lamnimargus himalayensis—Waterhouse & Gupta 1983b: 237, pl. 1, fig. 10, pl. 3, fig. 5.

'*Lamnimargus*' *himalayensis*—Angiolini in Garzanti et al. 1996: 194, pl. 1, figs 1–2.

Description This species is represented by three ventral valves, NMV P145674, P145676 and P145677, including a fragmentary ventral external mould. The specimens are small, 25 mm wide and about 22 mm long, transverse in outline, widest along hinge line; moderately convex; ears relatively large, lobate in shape, well demarcated from umbonal slopes; visceral disc moderately convex, sharply geniculated anteriorly into trail; sulcus prominent, commencing about 4 mm from umbo, deepest over middle valve. Ventral ornament consists of well defined costae and concentric rugae, the latter being confined to visceral disc area; reticulation pattern poorly preserved due to abrasion; costae generally uniform in strength, low but clearly recognisable, 8 to 9 per 10 mm at midlength, no bifurcation or intercalation observed, no sign of convergence in sulcus. Ventral spines poorly preserved, but one pair of strut spine bases are seen, one on each flank near sulcus.

Ventral adductor and diductor scars partially observed, weakly striated; valve floor anterior to the muscle scars covered by close-set, well-differentiated endospines, becoming finer towards marginal ridge, no endospines on interior of trail; marginal ridge weak, no anterior flanges observed.

Comments. The present specimens are poorly preserved; however, their shape, size and characteristics of the ears, the low but well-defined costae and details of the sulcus suggest a close similarity to *Lamnimargus himalayensis* Diener (1899) from the lower Zewan Formation of Kashmir. The Selong specimens are generally smaller than the syntypes figured by Diener, but this seems to be a variable feature. For instance, Gupta & Waterhouse (1979) also figured a small, reticulate ventral valve as *Lamnimargus himalayensis*. This is also true of the specimens figured as the same species by Zhang & Jin (1976, pl. 10, figs 17–21).

Occurrences. *Lamnimargus himalayensis* seems to have a restricted stratigraphical and geographical distribution. As discussed earlier, this species is the key form of the *Lamnimargus himalayensis* Zone which is widely distributed in the Himalayan region. It has been recorded from Pakistan, Bhutan, Nepal, southern Tibet, Kashmir, northwest India, Sikkim and Karakorum. The occurrences of the species from Cambodia as recorded by Chi-Thuan

(1961, pl. 1, figs 12–14; 1962, pl. 2, fig. 4) and from Beishan of northern Gansu Province, northwest China (Ustritskiy 1963, pl. 5, fig. 3) require verification; these specimens are characterised by finer, more closely set and more prominent costellae. Specimens figured as *Probolionia himalayensis* (Diener) by Grunt (in Grunt & Dmitriev 1973, pl. 5, figs 13, 14) are small, but with relatively large transverse ears and a more transverse viseeral disc. Personal inspection by GRS of the Pamirian species at the Palaeontological Institute of the Russian Academy of Sciences in August 1995 revealed a very narrow visceral cavity and a deep and relatively narrow sulcus, suggesting either *Uraloproductus* Ustritskiy or *Retimarginifera* Waterhouse. Archbold (1984: 115) had previously assigned the Pamirian material to *Retimarginifera*.

?**Lamnimargus** sp.

Fig. 3F

Comments. A poorly preserved ventral valve NMV P145675 in the Selong collection seems to suggest a different species closely related to *Lamnimargus* or an allied genus, but with clear difference from the species described above. The ventral valve is compatible in size, shape, sulcus to *Lamnimargus himalayensis* Diener but characterised by distinctively high, coarse costellae numbering 5 to 6 per 10 mm at midlength; some of the costellae tend to bifurcate near the anterior margin.

Family COSTISPINIFERIDAE
Muir-Wood & Cooper, 1960

Genus **Echinauris** Muir-Wood & Cooper, 1960

Type species. *Echinauris lateralis* Muir-Wood and Cooper, 1960.

?**Echinauris** sp.

Fig. 3D

Echinauris opuntia (Waagen), Zhang & Jin 1976: 173, pl. 7, fig. 9.

Comments. A possible species of *Echinauris* is indicated by a ventral valve NMV P145673 in the Selong material. The specimen is measured 32 mm wide and 34 mm long, subcircular to slightly elongate in outline, strongly convex without distinct geniculation, no sulcus; umbo strongly incurved over hinge; viseeral disc strongly convex with high and steep umbonal slopes; ears not preserved, maximum width possibly located at midlength. The only preserved patch of ventral exterior shows presence of very fine spine bases, about 1 to 1.5 mm in diameter, possibly quincuncially arranged, no costellae or concentric rugae are observed on the preserved patch of the ventral exterior although a pair of concentric lamellae are imprinted on the internal mould near the anterior margin.

Ventral muscle sears located on posterior third to quarter of valve floor; adductor scars on low, narrow median platform, possibly smooth; diductor scars weakly depressed, smooth or weakly striated. Numerous fine pustules or granules present anterior to muscle scars, about 1 mm in diameter.

This single specimen is possibly conspecific with *Echinauris opuntia* (Waagen 1884: 707, pl. 79; figs 1–2; Grant 1976: 27, pl. 8, figs 1–8; pl. 9, figs 1–8) from the Kalabagh Member of the Wargal Formation of the Salt Range, Pakistan, in terms of the observed details of the ventral valve in hand. However, detailed comparison is hampered by the lack of sufficient material, especially the absence of dorsal details. The Selong specimen shares with the Pakistani species a subquadrate outline, a strongly incurved ventral umbo and fine, numerous spines over the venter. However, because of the lack of dorsal details the possibility of this specimen belonging to other closely related Costispiniferidae genera, such as *Costispinifera* Muir-Wood and Cooper, cannot be ruled out.

A poorly preserved ventral valve figured as *Echinauris opuntia* by Zhang & Jin (1976: 173, pl. 7, fig. 9) from the Selong Formation of Tingri is considered conspecific; it shares all the observable features with those of the present specimen.

Order ATHYRIDIDA Dagys, 1974

Superfamily ATHYRIDACEA McCoy, 1844

Family ATHYRIDIDAE McCoy, 1844

Genus **Cleiothyridina** Buckman, 1906

Type species. *Atrypa pectinifera* Sowerby, 1840.

Cleiothyridina sp.

Fig. 4A.

Comments. One dorsal valve NMV P145688 with part of a ventral posterior attached is indicative of the presence of *Cleiothyridina* in the Selong assemblage. The dorsal valve is about 3 cm wide and 2.5 cm long, subcircular in shape; gently

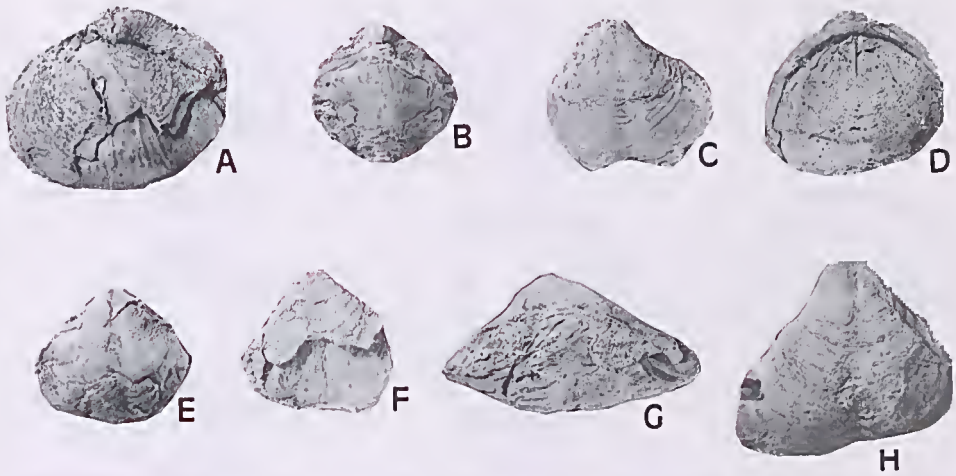


Fig. 4. A, *Cleiothyridina* sp., dorsal valve with part of ventral valve attached, NMV P145688, ×1. B–H, *Posicomta grunti* n. sp.: B, E, G, holotype, dorsal, ventral and anterior views of an articulated shell, NMV P145689, B, E, ×1; G, ×1.5; C, ventral valve, NMV P145693, ×1; D, dorsal view (showing the internal mould) of an articulated shell, NMV P145691, ×1.5; F, ventral view (showing part of the exposed ventral internal mould) of an articulated shell, NMV P145690, ×1; H, ventral valve, NMV P145692, ×2.

to moderately and evenly convex, with no conspicuous fold. Fine, close-set concentric lamellae prominent, about 2 per 1 mm near anterior margin; the anterior edge of each laminae 'saw-teeth' fringed, indicating the attachment of fine spines along the edge of the lamellae. Dorsal interior marked by distinct radial vascular markings, which tend to subdivide towards anterior margin.

This single specimen is most likely to be conspecific with specimens attributed to *Cleiothyridina royssii* (Eveillé) from the Wargal and Chhidru Formations of the Salt Range (Davidson 1862: 27, pl. 1, fig. 6; Waagen 1883: 475, pl. 39, fig. 10; pl. 30, figs 6–12) in terms of shell size, convexity and shape. *C. capillata* (Waagen 1883: 479, pl. 39, figs 6–9; pl. 40, figs 1–5; pl. 42, figs 1–5; Grant 1970: 141, pl. 2, figs 16–17) from the upper Chhidru Formation is also close in shell size and outline, but is readily distinguishable from the present specimen by its high convexity.

Family SPIRIGERELLIDAE Grunt, 1965

Genus Posicomta Grunt, 1986

Type species. Posicomta gundarensis Grunt, 1986.

Diagnosis (Grunt 1986: 120). Shell small, length about equal to width; subpentagonal in outline, moderately biconvex, both valves with equal convexity; sulcus weak, fold normally absent but a furrow or fine groove may be present along the median symmetry plane of some dorsal valves. Umbo low, moderately incurved; foramen small to moderately large, rounded. Delthyrium broad, triangular in shape, completely concealed by dorsal umbo. Shell surface normally smooth or with weak concentric growth lines only along the anterior margins of shell.

Ventral interior with teeth and short, divergent dental plates; teeth small, pointing inwards. Dorsal interior with inner and outer hinge plates and a weak median septum; inner hinge plates depressed below outer hinge plates; median septum usually small, never connecting to hinge plates. Ventral muscle impressions weak, lobate in shape. Shell strongly thickened; shell structure consists of two layers, primary layer made of fine, prismatic calcite micro-crystals and second layer fibrous; fibres large.

Discussion. This genus is closest to *Composita* Brown and *Tulathyris* Grunt, from the former it may be distinguished by its small size and thick shell, and from *Tulathyris* it differs by its thick shell. *Spirigerella* Waagen also shares some general morphological characteristics with *Posicomta* but is distinguished in having its greatest width typically placed anterior to midlength, a short, usually strongly incurved beak with no or a small foramen, and ill-defined dental plates.

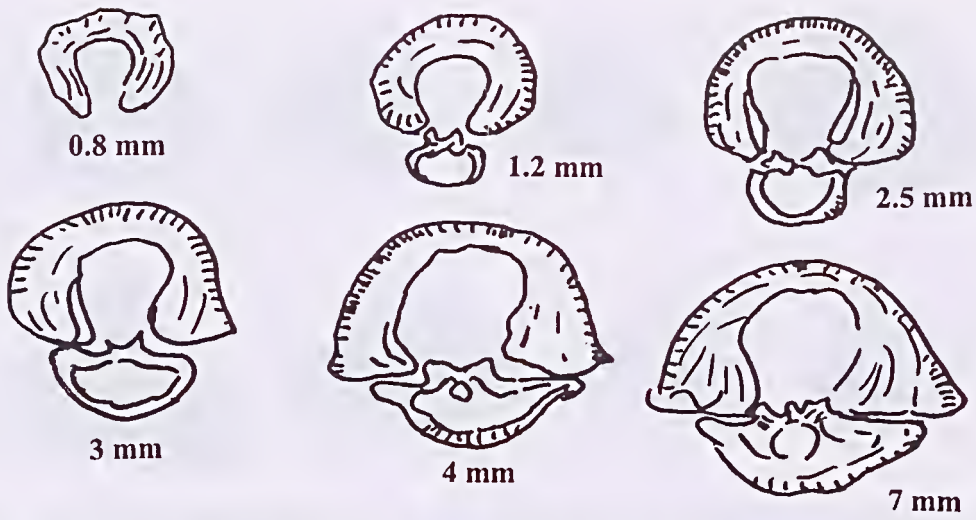


Fig. 5. Serial sections of *Posicomta grunti* n. sp. Numbers adjacent to the figures indicate distances in mm from umbo, all ×3.

Posicomta grunti n. sp.

Figs 4B–H, 5

Etymology. In honour of Dr T. A. Grunt, a respected colleague and teacher, who also examined this species while visiting Australia in December 1996.

Material. Four articulated shells NMV P145688–P145691 and one ventral valve NMV P145692.

Holotype. NMV P145689, an articulated shell figured in Figs 4B, E, G.

Diagnosis. Shell medium to large, subovate in shape, both valves equally convex; median groove prominent on ventral valve, variable on dorsal valve; anterior commissure uniplicate. Dental plates ill-defined, mostly buried within posterior shell wall. Dorsal interior with a prominent median septum.

Description. Shell medium to large, 1.5 to 3.5 cm wide, 1.6 to 2.5 cm long, and 0.8–?1.3 cm thick, subovate in outline with maximum width at midlength; both valves moderately to strongly and equally convex, with greatest convexity at midlength; umbo narrow with umbonal slopes converging posteriorly at about 15–20°, umbonal slopes gently to moderately concave in profile, high and steep; beak elongated, moderately incurved; foramen relatively small, mostly obscured by matrix; delthyrium totally concealed by dorsal beak. No obvious sulcus or fold except at anterior margin the commissure is clearly uniplicate in the holotype (Fig. 4G); a prominent median groove present in all ventral valves, commencing from beak and extending and broadening towards anterior margin; no prominent corresponding median groove seen on dorsal valve.

Shell surface smooth except for a few broadly spaced concentric growth lines or lamellae concentrated on anterior two thirds of shell; posterior third of shell smooth.

Specimen NMV P145692 was sectioned to reveal internal structures (Fig. 5). No clear, isolated dental plates found within posterior 2 mm from umbo, but a pair of thin, darkened ridges observed from a thin section at about 2.5 mm from umbo, still attached to the shell wall; the darkened colour can be clearly distinguished from the white, prismatic microcrystals of calcite that make up the second layer of the shell structure. In holotype, a pair, almost parallel, of darkened ridges were also observed from the umbonal area (at about 1–2 mm from beak) under microscope. Hinge plates subquadrate in shape, medially concave. Dorsal median septum prominent, extending for 5–8 mm from beak. Ventral muscle field only partially observable in specimen NMV P145690 (Fig. 5F), lobate and relatively large, occupying about posterior third of valve floor, slightly depressed; moderately striated; vascular markings present, prominent around muscle field, weaker towards lateral and anterior margin.

Shell structure of two distinct layers; primary layer of fine, prismatic (perpendicular to shell

surface) calcite crystals; second layer (outer layer) of microscopic calcite fibres parallel or at low angle to shell surface.

Comparison. The new species is particularly close to the type species *Posicomta gundarensis* Grunt (1986: 120, pl. 16, figs 9–11; fig. 63) from the Kubergandian Gundaren Formation of southwest Darvas in the Pamir Range. The two species share a similar size, suboval shape and, in particular, a prominent median groove on the ventral valve and a variably developed median groove on the dorsal valve. However, the new species shows a more elongated and attenuated umbo and beak, resulting in more concave umbonal slopes. A comparison of the thin sections of the new species with those of *P. gundarensis* also reveal some significant internal differences. The dental plates in the type species are separated from the thickened shell material almost from the beak, whereas they appear to be buried in the shell material for almost their entire length in the new species. No dorsal median septum seems to have been revealed in the sectioned specimen of *P. gundarensis* although the genus was diagnosed as having a weak dorsal median septum. This is in contrast to a prominent median septum in the dorsal interior of the new species.

Four other species have also been assigned to *Posicomta*. *P. zaalaica* Grunt (Grunt 1986: 122, p. 16, figs 12, 13) from the Kubergandian beds of the Trans-Alaica Range in Turkestan is a small species lacking median grooves on both valves. Three species described by Grant (1976) as *Composita* from the Rat Buri Limestone of southern Thailand have been transferred to *Posicomta* by Grunt (1986). *P. adverna* (Grant 1976: 205, pl. 56, figs 1–60) and *P. dolabrata* (Grant 1976: 206, pl. 57, figs 21–31) are both smaller than *P. grunti*, with a conspicuous triangular shape due to its elongated and posteriorly narrowed and pointed umbonal region. *P. subsolana* (Grant 1976: 209, pl. 57, figs 1–17) is the largest of the three Thai species, approaching the largest specimen of the new species; it also has a well developed dorsal median septum, resembling the new species. However, the anterior commissure of the Thai species is more strongly uniplicate, some even sulciplicate. The Thai species also lacks the characteristic median grooves of *Posicomta grunti*.

Order SPIRIFERIDA Waagen, 1883

Superfamily SPIRIFERACEA King, 1846

Family SPIRIFERELLIDAE Waterhouse, 1968

Genus **Spiriferella** Chernyshev, 1902

Type species. *Spirifer saranae* Verneuil, 1845

Comments. The familial status of *Spiriferella* and allied genera is still of debate (Carter 1974; Archbold & Thomas 1985; Angiolini 1995). Termier & Termier (in Termier et al. 1974) recognised the distinctiveness of the spiriferid group and proposed Spiriferellidae as a new family, apparently unaware of the earlier proposal by Waterhouse (1968). Shi & Waterhouse (1996), in accepting Termier & Termier's proposal, have also recognised the validity of the family Spiriferellidae. This family now includes 7 genera in addition to *Spiriferella*: *Elivina* Fredericks, *Eridmatus* Branson, *Alispiriferella* Waterhouse & Waddington, *Plicatospiriferella* Waterhouse & Waddington, *Timaniella* Barchatova, *Rhombospirifer* Duan & Li and *Hunzina* Angiolini. A possible additional genus, *Tintoriella* Angiolini (in Garzanti et al. 1996), may be also included (see Discussion below).

Distinction of *Spiriferella* from *Elivina*, *Eridmatus*, *Alispiriferella*, *Plicatospiriferella*, *Timaniella* and *Rhombospirifer* have been discussed in some detail by Waterhouse et al. (1978), Waterhouse & Waddington (1982), Archbold & Thomas (1985) and Shi & Waterhouse (1996). *Hunzina* was considered by Angiolini (1995: 187) to differ from *Spiriferella* by its 'open delthyrium, lower dorsal fold, less fasciculated ornamentation, shorter dental plates which are strongly embedded in the apical callus'. However, the practicality of using the presence or absence of a pseudodeltidium as one of the key diagnostic characteristics in distinguishing Spiriferellinae genera needs to be cautioned because the lack of a pseudodeltidium which may be originally present may well be due to preservation. This is evident, for instance, from the illustration of *Spiriferella gravis* Cooper & Grant (1976: 2230, pl. 630, figs 1–40) from the Word Formation of west Texas of the United States. Most of their figured ventral vales (eg. pl. 630, figs 17, 29, 31, 33) clearly show the presence of a convex pseudodeltidium over the delthyrium, but others (eg. pl. 630, figs 27, 39) show no sign of such a structure, which has presumably been broken.

Tintoriella Angiolini (in Garzanti et al. 1996) was based on large specimens of *Spiriferella rajah* (Salter) from the northwest Himalayas and was distinguished from *Spiriferella* by means of 'the open delthyrium, longer dental plates and adminicula which are not embedded in the apical callus' (Angiolini in Garzanti et al. 1996: 195). However,

as described below, a well preserved ventral internal mould of what is believed to be *Spiriferella rajah* from the Selong Formation does not exhibit the isolated adminicula as observed by Angiolini. In this specimen, almost the entire adminicula seem to be buried within the secondary shell thickening below the delthyrium. This may imply that the contact relationship between the adminicula and the posterior shell wall is a variable feature, presumably reflecting ontogenetic changes and/or environmental control. In some specimens, for instance the ventral interior of *Spiriferella rajah* figured by Diener (1915, pl. 9, fig. 6), the adminicula are apically buried within the shell wall but anteriorly become separated . The same seems also true with '*Tintoriella*' *rajah*, judging from its serial sections figured by Angiolini (in Garzanti et al. 1996, pl. 1, figs 8–13). In this sectioned specimen, the adminicula do not become separated from the apical callus until about 5.5 mm from the beak. The variable feature of the adminicula in relation to the apical callus in *Spiriferella* and allies has also been demonstrated by Waterhouse & Waddington (1982) from a large collection of specimens from western and northern Canada (eg. *Spiriferella saranae* sectioned by Waterhouse & Waddington 1982, fig. 14).

On the other hand, the Selong ventral valve (Fig. 6A) does show an open delthyrium and a pair of thickened, subparallel dental plates, but it cannot be ascertained from the specimen whether or not the delthyrium was originally open or closed by a pseudodeltidium. For the above reasons, *Spiriferella* is retained for Salter's species.

Spiriferella rajah (Salter, 1865)

Figs 6A–I

Spirifer rajah Salter in Salter & Blanford 1865: 59, 111, 2 figs in p. 59.
Spirifer rajah—Davidson 1866: p. 40, pl. 2, fig. 3.
Spirifer rajah—Diener 1899: 68, pl. 4, figs 1–7; pl. 5, fig. 1.
Spirifer rajah—Diener 1903: 105, 131, 186, pl. 4, figs 3–5.
Spiriferella rajah—Waterhouse 1966: 48, pl. 1, fig. 5; pl. 3, fig. 2; pl. 7, figs 1, 2, 4; pl. 11, fig. 2; pl. 12, fig. 2.
Spiriferella rajah—Muir-Wood & Oakley 1941: 36, pl. 2, figs 2, 3, 9–11.
Spiriferella rajah—Zhang & Jin 1976: 215, pl. 17, figs 3–12.
Spiriferella rajah—Waterhouse in Gupta & Waterhouse 1979: 11, pl. 1, figs 10–14; pl. 2, figs 1–10; pl. 3, fig. 1.
Spiriferella rajah—Waterhouse & Gupta 1983b: 238, pl. 2, figs 1–2.
Spiriferella rajah—Brookfield & Gupta: 1984, figs 5, 6, 8.
Spiriferella rajah—Garzanti et al. 1992: 280.
Spiriferella rajah—Garzanti et al. 1994: pl. 1, fig. 5.
Tintoriella rajah—Angiolini in Garzanti et al. 1996: 195, pl. 1, figs 6–13.

Diagnosis. Large, subquadrate to slightly elongate *Spiriferella*; shell maximum width normally at hinge or slightly anterior to it; ventral umbo massive, strongly incurved; dorsal fold lacking median groove; plicae prominent, low, well rounded, separated by narrow interspaces, strongly costate, each plica consisting of up to 7 costae.

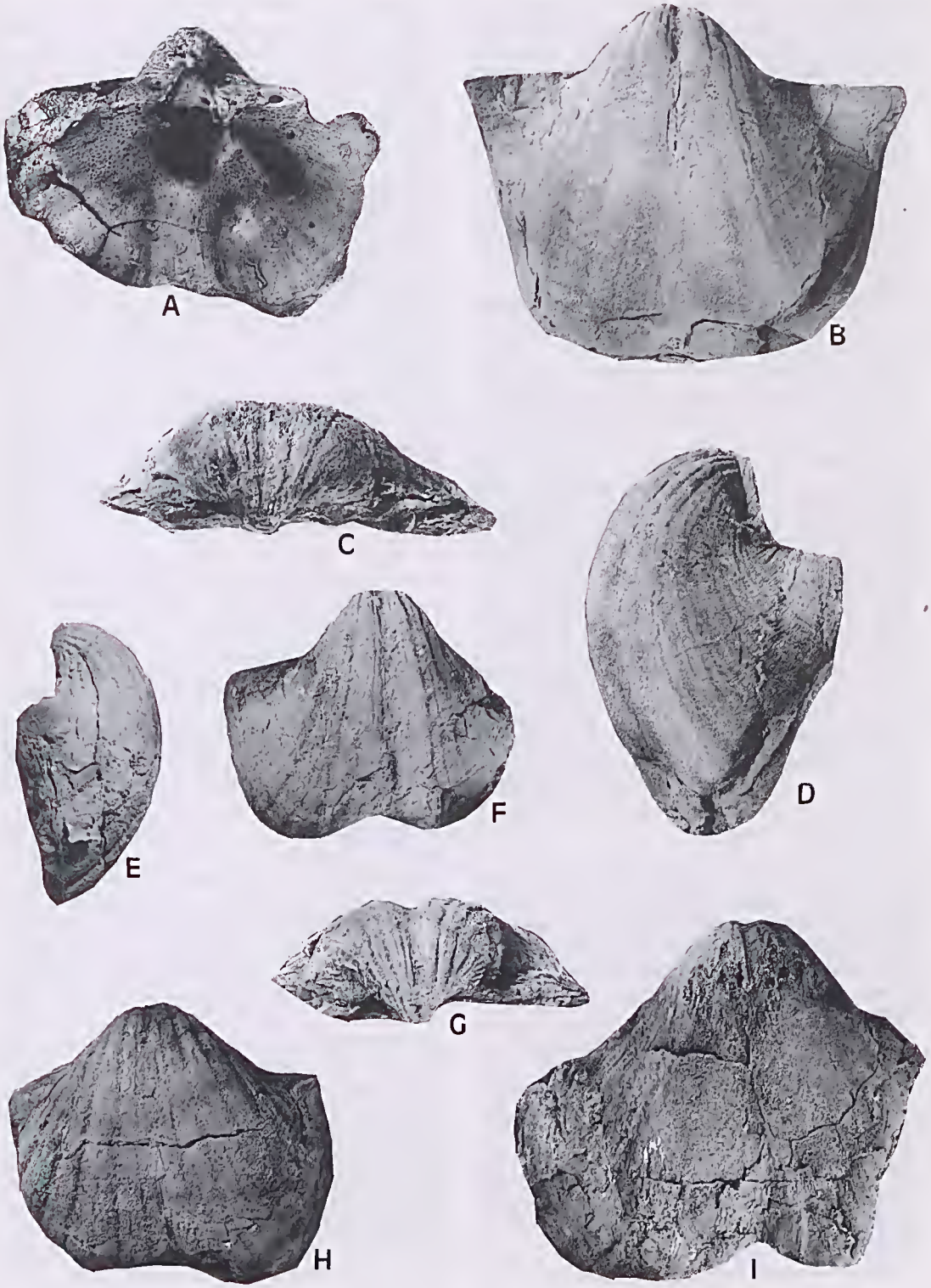
Material. Seven ventral valves and one ventral internal mould, of which five are figured herein, NMV P145678–P145682.

Description. Shell large, maximum width 68 mm, length more than 55 mm; subquadrate in outline, widest at hinge line or slightly anterior to it. Interarea relatively small, high, triangular in shape, moderately concave, weakly marked by striations; delthyrium relatively large; pseudodeltidium unknown.

Ventral valve strongly and evenly convex, maximum convexity at midlength; umbo massive, strongly incurved with beak hanging over delthyrium; umbonal slopes high and steep, straight or gently inflated in outline, diverging anteriorly at about 65° to 70°; ears large, well extended laterally, triangular in shape, flattened in profile, clearly segregated from venter by angle close to 80–90°. Sulcus prominent, commencing from umbo, widening forwards at about 20°, moderately deep, clearly defined by first pair of plicae, sulcal floor V-shaped in section, floor angle (measured at anterior margin) varying from 110° to 114°. Lateral flanks rounded in cross section with relatively high and steep slopes.

Five to six pairs of plicae observed on all ventral valves, commencing from umbo where they are clearly separated from each other by interspaces equal to or slightly narrower than plicae; anteriorly,

Fig. 6. Spiriferella rajah (Salter). A, ventral valve, NMV P145678. B, D, ventral and lateral views of a ventral valve, NMV P145679. C, I, posterior and ventral views of a ventral valve, NMV P145680. E, G, H, lateral, posterior and ventral views of a ventral valve, NMV P145681. F, ventral valve, NMV P145682. All in natural size.


A
B
C
D
E
F
G
H
I

plicae tend to be lower, more flattened, well rounded in section, and less clearly demarcated from each other due to fasciculation; first bifurcation of plicae occurs at about 10 to 15 mm from beak; secondary costation appears at about midlength; in some specimens, particularly larger ones (Figs 6B, D), further branching of plicae seems evident at near anterior margin resulting in equi- or nearly equidimensional costate appearance in some specimens; up to three pairs of costae observed in sulcus, with no prominent median costa.

Micro-ornament is preserved on parts of one ventral valve (NMV P145679, Fig. 6D), consisting of relatively well defined lamellae, crossed by very fine radial capillae; lamellae numbering 2 to 3 per mm and capillae 3 to 4 per mm on ears; fine, low pustules arise from capillae, often at intersections with concentric lamellae, numbering 2 to 3 per mm.

Umbonal area of ventral interior strongly thickened, resulting in a thick apical callus just below posterior part of delthyrium; teeth robust, probably also thickened, supported by prominent dental plates, which, along with low adminicula, are posteriorly buried by apical callus; muscle field relatively short, posteriorly placed below delthyrium, clearly delineated from the rest of valve floor by raised, posteriorly thickened surrounding ridges, oval or diamond in shape, deeply depressed posteriorly and raised in front where it then passes into a narrow, high supporting ridge, anteriorly striated; muscle field bisected by a fine median ridge commencing from apical callus; adductor and diductor scars poorly differentiated; areas surrounding the muscle field covered by vascular markings.

Comparisons. The diagnosis of *Spiriferella rajah* given above is based on the illustrations and descriptions of the species provided by Salter (in Salter & Blanford 1865) and Davidson (1866) in conjunction with observations made from the present material. A comparison of Salter's original drawings of *S. rajah* with those of Davidson reveals two discrepancies, presumably a reflection of artistic interpretation or intraspecific variations. The specimen illustrated by Salter shows that the maximum width of the species is at hinge line and the dorsal fold is as strongly costate as plicae on lateral flanks. These two features are in contrast with the relatively short hinge (shorter than the maximum width) and a largely smooth or weakly costate fold depicted for the same species by Davidson.

The Selong specimens at hand can be closely compared with *Spiriferella rajah* of Salter in shell shape, a wide hinge that represents the maximum width of the shell, a massive and strongly incurved umbo, and costate sulcus and fold. The two illustrations of *S. rajah* given by Salter are smaller than the largest specimens described here (NMV P145679) but are well compatible with the other ventral valves such as NMV P145678, NMV P145681–P145682.

The species has been previously recorded from many localities, only some of which are considered to be truly conspecific with the type material based on the diagnosis given above for the species (see synonymy list). Other forms that have also been recorded under the same species name but whose morphological features are inconsistent with the diagnosis herein provided have been exeluded from the synonymy, as discussed below. *Spiriferella rajah* is readily distinguished from most other species of *Spiriferella* by its large size, subquadrate outline, wide hinge normally marking the maximum width of the shell, a massive, strongly incurved umbo, and low, broad, well-rounded and strongly costate plicae. Some of these features are shared with several large *Spiriferella* found in the Kazanian–Midian beds of northeast Asia and Australia. Fredericks (1916) recognised six varieties/forms (or subspecies) of *Spiriferella rajah* from the lower Upper Permian of the Russian Far East. Identity of these forms with true *Spiriferella rajah* has been questioned by Li (in Ding et al. 1985), who grouped and reclassified them into two species: *Spiriferella magna* Fredericks and *S. saranaeformis* Fredericks. The former, which also occurs in the Permian Zhesi Formation of Inner Mongolia, is a large subquadrate to subrounded *Spiriferella*; it differs from *S. rajah* by its narrow hinge line and a broad and deep sulcus. *S. saranaeformis* is comparable with *S. rajah* in size but has an elongate outline coupled with a high and strongly incurved interarea (rather like typical *S. saranae*). Grabau (1931) also assigned several large specimens from the Zhesi Formation respectively to *Spiriferella salteri* (Chernyshev) and *S. keilhavii* (von Buch). These Inner Mongolian specimens resemble *S. rajah* in size and the broad hinge line that marks the shell maximum width, but they both have high and weakly costate plicae, in contrast to the low, broad and strongly costate plicae of *S. rajah*.

Spiriferella grandis Kotlyar (in Likharev & Kotlyar 1978: 73, pl. 18, figs 7–8) from the Midian Chandalaz Formation of the Russian Far East is very close to the Selong material in shell size and shape, but seems to have a broader and deeper sulcus and more prominent plicae separated by

deeper interspaces. Archbold (1995) also figured a large, subquadrate *Spiriferella* from a deep drilling core of the northern Perth Basin of Western Australia, believed to be of Ufimian age; however, this Australian species has a relatively narrower hinge and its maximum width is near the anterior margin.

Occurrences. As implied by the synonymy list of *Spiriferella rajah* shown above, this species is widely distributed in the Himalayan region where it has been recorded from northern Pakistan, Nepal, southern Tibet, Kashmir, northwest India, and Sikkim. The species appears to be restricted to the *Lamnimargus himalayensis* Zone of Midian–Early Dzhulfian age.

Family SPIRIFERIDAE King, 1846

Subfamily NEOSPIRIFERINAE Waterhouse, 1968

Genus Neospirifer Fredericks, 1924

Type species. *Spirifer fasciger* von Keyserling, 1846.

Neospirifer kubeiensis Ting, 1962

(emend. Chang emend. nov. 1976)

Figs 7B–D

Neospirifer moosakhailensis Ting 1962: 452, pl. 1, figs 1–6.
Neospirifer kubeiensis Ting 1962: 453, pl. 2, figs 1–3.
Neospirifer Tibetensis Ting 1962: 454, pl. 2, figs 4, 5.
Neospirifer kubeiensis—Zhang in Zhang & Jin: 1976, 203, pl. 14, figs 1–4, 8–9; pl. 15, figs 1, 2; pl. 16, fig. 8; pl. 19, fig. 2; figs 10, 11).
Neospirifer kubeiensis—Waterhouse 1978: 125, pl. 24, figs 4–7.
Neospirifer tibetensis—Yang & Zhang 1982: 312, pl. 3, figs. 2–4; fig. 1.
Neospirifer kubeiensis—Yang et al. in Yang & Nie 1991: pl. 25, fig. 9.
Neospirifer kubeiensis—Fang & Fan 1994: pl. 31, figs 10–12; pl. 32, figs 1, 2 (see also Fang 1995: 140, pl. 5, figs 10–12; pl. 6, figs 1, 2).

Description. This large *Neospirifer* species is represented by three ventral valves, one of which is nearly complete. The shell is moderately transverse, 94 mm wide and 60 mm long; subtrigonal in shape; gently and evenly convex in profile. Umbo moderately incurved with umbonal angle close to 110°; umbonal slopes low, broadly rounded in cross section, gently concave in profile. Interarea low (about 14 mm high), broadly triangular in shape; delthyrium concealed by sediment. Hinge line wide, equal to or slightly narrower than the maximum width of shell; cardinal extremities blunt with cardinal angle about 90°. Sulcus very pronounced, commencing from umbo, 5 mm wide at 10 cm from umbo and increasing to about 40 mm wide near anterior margin; sulcal floor broadly rounded, sulcal height close to 10 cm, deepest at anterior margin.

Shell ornament consisting of three pairs of prominent plicae on lateral flanks, one pair of plicae on sulcal slopes, equidimensional costae on both flanks and in sulcus, and a well-defined median costa within sulcus. Plicae broad, relatively low and rounded in crest, decreasing in strength towards cardinal extremities so that areas of flanks near cardinal extremities are nonplicate but covered by fine costae; plicae asymmetrical in cross-section with its broader and more gentle slope oriented towards sulcus; each plica consisting of a bunch of up to 6 equidimensional costae each about 1.4 mm across. Pair of plicae on sulcal slopes much weaker than those on flanks, most pronounced over posterior third of sulcus where they define the initial edges of sulcus from flanks, becoming progressively weaker anteriorly until they are completely and evenly dispersed as costae within the sulcus. Costae within the sulcus equidimensional, each about 1.4 mm across, about 15 on each sulcal slope; median sulcal costa distinct, slightly coarser than other sulcal costae, persisting from umbo to anterior margin.

Comments and comparisons. Ting (1962) recognised three large *Neospirifer* species from the upper Permian of southern Tibet: *N. moosakhailensis* (Davidson), *N. kubeiensis* Ting and *N. tibetensis* Ting, based on the relative size of shell, number of plicae on flanks and costae within sulcus, and the width of hinge with respect to shell maximum width. Zhang & Jin (1976) examined some 45 specimens representative of all the three species from southern and central Tibet and observed that the criteria used by Ting were features of considerable variation, which they believed to be primarily related to ontogenetic changes. As a consequence, Zhang & Jin broadened the definition of *N. kubeiensis* as originally outlined by Ting to accommodate a wide range of variation and included *N. tibetensis* as a junior subjective synonym of *T. kubeiensis.*

As also noted by Zhang & Ching (1976), *N. kubeiensis* is very close to *N. moosakhailensis* (Davidson 1862, pl. 2, fig. 2) from the Wargal and Chhidru Formations of the Salt Range, agreeing in size, shape, and plication and costation patterns, but the Pakistani species, the lectotype of which was refigured by Waterhouse (1978, pl. 26,

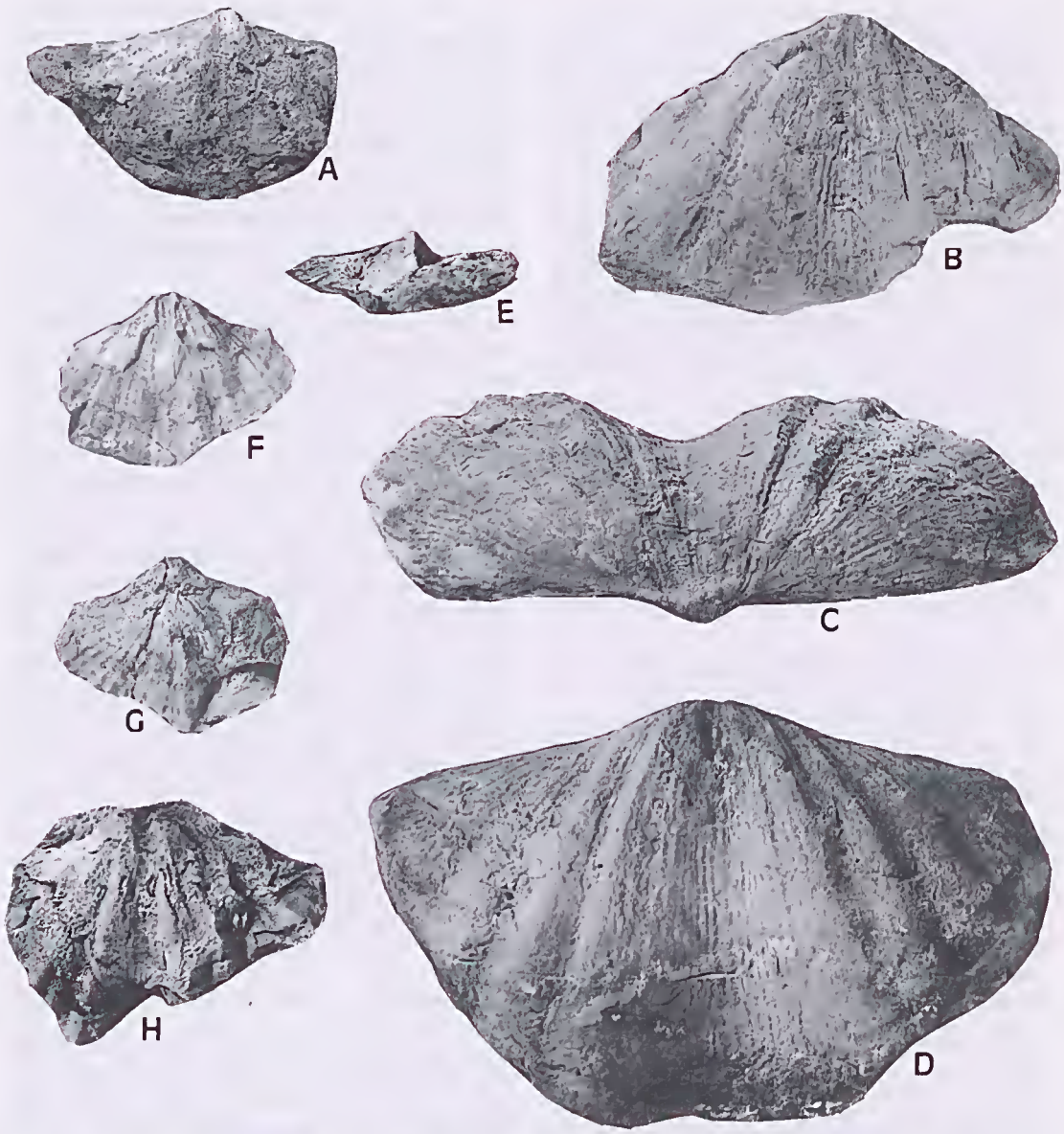


Fig. 7. A, E–G, *Trigonotreta* sp.: A, ventral valve, NMV P145683, ×1; E–G, anterior, ventral and dorsal views of articulated shell, NMV P145684, ×1. B–D, *Neospirifer kubeiensis* (Ting): B, ventral valve, NMV P145687, ×1; C–D, posterior and ventral views of ventral valve, NMV P145685, ×1. H, Spiriferinacean gen. et. sp. indet., ventral valve, NMV P145686, ×2.

figs 4–7), lacks a pair of subplicae within the sulcus that otherwise characterises *N. kubeiensis*.

The moderatcly transversc outlinc, strong and distinct lateral plications, a broad and deep sulcus with a pair of weak sulcal plicae of *N. kubeiensis* suggest similarities to a group of large to moderately large *Neospirifer* specics from the Sakmarian–Artinskian beds of Western Australia (Archbold & Thomas 1986), including *Neospirifer foordi* Archbold and Thomas, *N. plicatus* Archbold

and Thomas and *N. postplicatus* Archbold and Thomas. The first of these species possesses a sharp, angular-floored sulcus lacking lateral plicae and its costae appear to be finer than those of the present material. The other two Western Australian species are closer to *N. kubeiensis* in many respects, particularly in terms of shell size, shape, strong plications, and sulcal plicae, but they both have attenuated cardinal extremities at maturity. *N. postplicatus* is further distinguished from *N. kubeiensis* in lacking the third pair of lateral plicae on flanks, which is prominent in *N. kubeiensis*.

Occurrences. *Neospirifer kubeiensis* has been recorded from the Wargal and Chhidru Formations of the Salt Range, Pakistan, the upper Kuling Group or equivalent beds in northwest Himalayas, the Selong Formation or equivalents in central and southern Tibet, and the Dadongchang Formation of western Yunnan, China.

Subfamily TRIGONOTRETINAE Schuchert, 1893

Genus **Trigonotreta** Koenig, 1825

Type species. *Trigonotreta stokesii* Koenig 1825.

Trigonotreta sp.

Figs 7A, E–G

Comments. The presence of *Trigonotreta* within the Selong collection is indicated by a decorticated ventral valve (NMV P145683) and an articulated shell (NMV P145684). Although there are only limited features observable, the Selong material, especially specimen NMV P145684 (Fig. 7E–G), does show the characteristic fascicles of *Trigonotreta*, with three costae derived from a primary plica. Specimen NMV P145683 also shows the typical trigonal shape of *Trigonotreta*, while specimen NMV P145684 is comparatively more transverse. The latter specimen also exhibits closely spaced concentric lamellae, 3–4 per mm, and a prominent median costa within the sulcus. The fold of specimen NMV P145684 is relatively narrow, high and sharp-crested. The inadequate preservation of the Selong form does not warrant any closer comparisons with described species.

Order SPIRIFERINIDA Cooper & Grant, 1976

Suborder SPIRIFERINIDINA Ivanova, 1972

Superfamily SPIRIFERINACEA Davidson, 1884

Spiriferinacean gen. et. sp. indet.

Fig. 7H

Comments. An incomplete, decorticated ventral valve with coarse, simple costae and a smooth sulcus probably indicates a Spiriferinacean genus in the Selong assemblage. The valve is more than 2 cm wide and more than 1.5 cm long, moderately convex. Sulcus prominent, relatively deep with sulcal floor broadly U-shaped, no costellae present within sulcus; at least four pairs of costae present on lateral flanks, simple and extending from umbo to anterior margin; relatively high and well rounded in section. No microornament is observable on the decorticated surface.

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